25X1

Model 1 Air-Fe Inc.

Rec'd EB 8/18/61 Art Joe Walt

[redacted]

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August 14, 1961

Dear Sir:

This letter summarizes the information which we obtained during our meeting with [redacted] Application Engineer, at the [redacted] on July 19, 1961, in connection with electric motors for incinerators.

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The electric motors used in the Model 1 and Model 2 incinerators fit into the following three categories, which have different service characteristics:

(1) Three-phase, 208,220/440-volt, 50/60-cycle dual-frequency, dripproof, standard Class A induction motors such as your 7-1/2-hp and 2-hp motors which are suitable for your application at altitudes up to 15,000 ft.

(2) Single-phase, 115/230-volt, special 50/60-cycle dual-frequency, dripproof, capacitor-start, standard Class A induction motors such as your special 2-hp motor which is presently adequate for your application at altitudes up to 3,300 ft. By redesigning and adding Class B insulation, GE can build this motor to satisfy your requirements at altitudes up to 15,000 ft.

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(3) Single-phase, 115/230-volt, either 50-cycle or 60-cycle single-frequency, dripproof, capacitor-start, standard Class A induction motors are suitable for altitudes up to 8,000 ft. GE recommends this type of single-frequency motor for consideration in preference to the above special dual-frequency motor, partly because the special motor is a compromise design and partly because you can have more than one motor supplier if you can use the widely available, standard, single-frequency motor. Presumably, this type of standard motor could also be redesigned to meet your needs at altitudes between 8,000 and 15,000 ft.

Three-Phase Motors

The present 7-1/2-hp and 2-hp, three-phase, standard motors have Class A insulation which permits a maximum temperature of 105 C (220 F) in the windings during operation. This provides for use at maximum ambient temperatures of 40 C (104 F); and thus allows for a temperature rise of 50 degrees C (90 degrees F) from resistance and an additional 15 degrees C (27 degrees F) for hot spots in the windings (40 C + 50 degrees C + 15 degrees C = 105 C). However, the 15-degree-C hot-spot allowance represents a safety factor and should be eliminated from consideration (by subtraction) when the temperature of the windings is checked with a thermometer or thermocouple. Thus, a maximum measured winding temperature of 40 C + 50 degrees C = 90 C or 194 F is allowable, and the maximum temperature of the outside housing is less than 194 F.

The temperature rise from resistance increases as the applied load is increased, and is somewhat higher for 50-cycle operation than for 60-cycle operation. At rated horsepower, the temperature rise is 40 degrees C (72 degrees F) at 60-cycle operation and 50 degrees C (90 degrees F) at 50-cycle operation.

In general, when these three-phase motors are operated on 60-cycle current, at altitudes up to 3,300 ft, at an ambient temperature of 40 C (104 F), and at rated voltage ± 10% and rated frequency ± 5%, they will deliver rated horsepower times a service factor (SF) of 1.15. Also, when operated on 50-cycle current, with the other conditions as indicated above, they will deliver rated horsepower times a SF of 1.0. In addition, if the ambient temperature is less than 40 C (104 F), both SF's will increase. For example, at 25 C (77 F) ambient temperature the SF's are increased by about 10 per cent; thus, for 60-cycle operation the SF is 1.25, and for 50-cycle operation, 1.10.

Beyond the general performance characteristics just mentioned, specific motors such as your three-phase 7-1/2 hp and 2-hp units have reserve capacity which allows their use at rated horsepower at altitudes above 3,300 ft. However, normally at higher altitudes, the decreased air density provides less effective cooling of the motors and consequently necessitates de-rating of the motors unless the specific designsprovide such reserve capacity.

For your three-phase 7-1/2-hp motor, this reserve is sufficient to provide for using the motor to obtain 7.5 x 1.15 = 8.6-hp output at altitudes up to 15,000 ft for ambient temperatures up to 40 C (104 F) and at rated voltage ± 10% for 60-cycle operation only. When this motor is operated with 50-cycle current under the same ambient temperature and voltage as above, the

rated output of 7-1/2 hp can be maintained at altitudes up to 8,000 ft. (This should reassure you that the present motor installed at the 7,600-ft site is adequate for the 16-7/8-in.-diameter blower wheel, which requires 5.6 hp at 2,900 rpm.) Above 8,000 ft the power which can be provided is reduced below 7-1/2 hp, but is still 5.6 hp at 15,000 ft; this is sufficient to drive the maximum-sized blower wheel (17-1/2-in. diameter) with the damper wide open. Therefore, the present standard 7-1/2-hp motor with Class A insulation appears to be adequate for your application under continuous use: (1) at all altitudes up to 15,000 ft, (2) at either 50- or 60-cycle operation, (3) at ambient temperatures up to 40 C (104 F), (4) at rated frequency ± 5%, and (5) at rated voltage ± 10%. In addition, this motor will tolerate occasional use at voltages as low as 20 per cent below rated voltage for periods of time up to 2 hours without appreciable shortening of the life of the motor. With regard to the life of electric motors, 10 years is considered a reasonable expected life. For each 10-degree-C increase in winding temperature above the maximum temperature of 105 C for motors with Class A insulation, the motor life is shortened by about 50 per cent.

For your 3-phase 2-hp motor, the design reserve is even greater than that for the 7-1/2-hp motor. At altitudes up to 15,000 ft, this motor will deliver 2.0 x 1.15 = 2.3 hp under 60-cycle operation, and 2.0 hp under 50-cycle operation, under the same conditions of ambient temperature, over and under voltage, and frequency variation as indicated above for the 7-1/2-hp motor.

Further, in regard to three-phase motors, only a small change of motor speed occurs when the applied load is increased. For example, the 7-1/2-hp motor has speeds as follows:

Load, hp	Speed, rpm
0	3,600
7-1/2	3,535
9	3,500
10	3,480
12	3,410

These minor changes in speed over the normal range of loads will not cause noticeable change in blower output.

Single-Phase Motors

Your present special, dual-frequency, 2-hp motor is adequate for its application at altitudes up to 3,300 ft when operated with either 50- or 60-cycle current. This motor was designed and built to represent a compromise for both 50- and 60-cycle operation and therefore has little reserve capacity. Furthermore, it is available only from GE; this represents a sole-source situation contractually, and also could cause a delay in procurement in the event of a strike at that plant.

As a result of our discussion concerning methods of maintaining rated power at altitudes above 3,300 ft, [redacted] replied by wire the 25X1 following day that such a dual-frequency motor could be operated up to 15,000 ft if it were modified to incorporate Class B insulation and thus permit the allowable winding temperature to be increased by 20 degrees C. This modification would change the model number which would be assigned at the time GE received an order for the motor from you. We did not discuss the cost of a motor of this type that was provided with Class B insulation; but, catalogue data show that the cost would be somewhat higher.

On the other hand, most of your needs for a 2-hp single-phase motor could be met by using a standard, Class A insulation, single-frequency motor which is available from several motor manufacturers. Of course, this would require that you know in advance the frequency of the electric power supply at the incinerator site. Standard motors available for either 50- or 60-cycle current are rated at the full 2 hp at altitudes up to 8,000 ft. Presumably, these motors could also be redesigned, using Class B insulation, to meet your needs at altitudes between 8,000 and 15,000 ft. [redacted] recommended that a standard single-frequency motor be used 25X1 instead of the special, dual-frequency motor, whenever possible.

Other Factors Regarding Purchase of Motors, Standby Generators, and Controls

Both standard and special motors produced by GE have the same factory delivery time of about 3 weeks. All GE motors are subject to 100 per cent quality control both on the parts and on the assembled motors; further, each motor is operated under the conditions marked on the nameplate of the motor.

When you order motors, the following should be specified:

(1) Voltage and phase

(2) Frequency

(3) Altitude of intended operation

(4) Maximum ambient temperature

(5) Actual horsepower required

(6) Type of motor shaft required.

In our discussion of the selection of adequately sized standby generators for your motor-blower assemblies, [redacted] showed us how the 25X1 code numbers of the motors tied in with values for the starting Kva per hp, as found on page 86 of the GE Bulletin No. GED-1691. In addition, Table 3 in the Onan bulletin, and other data in the Kohler and Fairbanks-Morse catalogues were discussed. Some difference of opinion seems to exist among the various generator manufacturers with regard to selection of appropriately sized units. Factors from 2.0 to 3.6 are used as multipliers of horsepower to determine Kw rating of the standby generator, and these still do not recognize the altitude factor. Our previous recommendations of 3.5- to 5.0-Kw-capacity units for the 2-hp motor and 10- to 15-Kw-capacity units for the 7-1/2-hp motor were regarded by [redacted] as being too low. He suggested 10- and 20-Kw- 25X1 capacity units for the 2-hp and 7-1/2-hp motors, respectively, to provide for some reserve. It would now seem advisable for you to review the whole situation, including the altitude factor and your apparent need to provide reserve generating capacity for lighting or other uses, before you make your final decision as to sizes of standby generators.

The effect of altitude on the operation of the heater elements in magnetic starters was also discussed briefly; [redacted] was unable to 25X1 advise us on what changes might be needed in the size of heaters used, to compensate for altitude. Subsequently, we have asked three local manufacturers' representatives about this and the Allen-Bradley representative is now waiting for an answer from the factory. As soon as we get the information, we shall transmit it to you.

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Table 1 is a summary of motor and starter data pertinent to the Model 1 and Model 2 incinerators. Each of the three columns shows (1) motor characteristics, (2) starter size, and (3) holding-coil numbers and heater-element numbers for various electrical conditions. The model numbers of the GE 2-hp motors will subsequently have to be changed; the present motors were ordered with a double shaft extension which is no longer needed. However, the extra length of shaft on the normal drive end of the 2-hp motor is still needed to fit the wheel of the No. 17 MW blower.

As you will notice, the full-load current is higher on 50-cycle than on 60-cycle frequency. Ordinarily, this would require that the number of the heater used be higher for 50-cycle use. However, in your application, the load on the motor is less at the 50-cycle blower speed; therefore, the same heater element can be used for both frequencies at a given voltage. It is emphasized that any possible effect of altitude on the selection of heater size is not shown in Table 1. We shall discuss this with you when we receive the appropriate information from Allen-Bradley.

The single-frequency, single-phase 2-hp motors discussed in this letter are not shown in Table 1. However, the same kind of magnetic starter, holding coils, and heater elements would be used with single-frequency motors as are shown, respectively, in Table 1 for the dual-frequency motor.

If you have questions or comments concerning the visit to the GE plant, please let us know.

Sincerely,

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TABLE 1. SUMMARY OF MOTOR AND STARTER DATA FOR THE MODEL 1 AND MODEL 2 INCINERATORS

	Model 1		Model 2			
Motor						
HP	7-1/2		2		2	
Phase	Three		Three		Single	
Voltage	208,220/440		208,220/440		115/230	
Frame No.	215		184		184	
Shaft dia., in.	1-1/8		7/8		7/8	
Shaft length, in.	Standard		3-1/2		3-1/2	
Present GE Model	5K215AG1		5K184AG1897		5KC184AG120	
Present GE Type	K		K		KC	
Present GE Code	G		K		J	
Frequency, cycles	60	50	60	50	60	50
Speed, rpm	3,500	2,900	3,500	2,915	3,500	2,950
Full-load current						
Lower voltage, amp	20	20+	5.6	6.2	20.8	27.0
Higher voltage, amp	10	10+	2.8	3.1	10.4	13.5
Temperature rise, C	40	50	40	50	50	50
Service factor	1.2	1.0	1.2	1.0	1.0	1.0
Magnetic Starter	Three phase		Three phase		Single phase	
Allen-Bradley, Bulletin No.	709		709		709 SP	
Size No.	1		0		1	
Form No.	1		1		1	
Type No.	1		1		1	
Frequency, cycles	60 or 50		60 or 50		60 or 50	
Allen-Bradley Holding Coils						
Frequency, cycles	60	50	60	50	60	50
110 volts, Coil No.	-	-	-	-	1L257*	1L289*
220 volts, Coil No.	1L06	1L07	0L06	0L07	1L257*	1L289*
440 volts, Coil No.	1L11	1L12	0L11	0L12	-	-
Allen-Bradley Heater Elements						
Frequency, cycles	60 or 50		60 or 50		60 or 50	
110 volts, Heater No.	-		-		N-39	
220 volts, Heater No.	N-39		N-25		N-31	
440 volts, Heater No.	N-31		N-18		-	

*Coils No. 1L257 and 1L289 are dual-voltage coils with three wire leads. All other coils are of the single-voltage type with two wire leads. Allen-Bradley may substitute single-voltage coils having a different stock number for the dual-voltage coils.

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File: Model 1 Air-Fed Inc.

25X1

August 17, 1961

Dear Sir:

This letter report summarizes the research performed under Task Order No. RR during the period from March 1 through June 30, 1961.

By March 1 the combustion-chamber section for the Model 2 incinerator had been constructed and fabrication of the two motor-blower compartments had been carried as far as possible without the blowers being available. The first blower, with a 3-phase, 208, 220/440-volt, 50/60-cycle motor, was received on February 28; the second blower, with a single-phase, 115/230-volt, 50/60-cycle motor, was received on March 8. A review of overseas electric-power systems was also made to explore the need for motor-blower assemblies other than the two types already provided. It was found that either the single-phase or 3-phase motors described above would be suitable almost throughout the world. The few exceptions, such as 160/280-volt, 50-cycle areas, would require the use of a special motor which can be manufactured in the same frame size as the present motors, and thus would fit without altering the blower.

Fabrication of the two motor-blower compartments was resumed in mid-April after an extension of the program was authorized. At the end of the period covered by this report, both motor-blower compartments were completed, and one base, attached to the combustion-chamber section, was operated in the course of a short burning trial.

In late April, an additional phase of research associated with the Model 2 incinerator was started under Task Order No. RR. It consisted of

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two parts: (1) the provision of a suitable emergency power source for the two motor-blower compartments of the present Model 2 incinerator, and (2) the investigation of the effect of altitude on the burning capacity of both the Model 1 and Model 2 incinerators.

As an emergency power source, a small gasoline engine was initially selected in preference to a diesel engine because of the high weight and cost of available diesel engines. Design efforts on a belt-drive arrangement or a flexible-shaft drive had been started, and a suitable gasoline engine had been selected when a decision to hold up on this part of the program was made during the meeting with you on May 19. At that time, you also requested that we assemble data on suitable gasoline-engine generators and diesel engines to provide a basis for a further review of the safety aspects of standby power for both the Model 1 and Model 2 incinerators.

Table 1 provides a summary of the data on standby power sources that were discussed at meetings with you and your associates on June 5 and 6. Subsequently, you decided that commercially available engine-generators will be used for standby power in the field, for both the Model 1 and Model 2 incinerators. Therefore, the effort on standby power sources was terminated.

Investigation of the effect of altitude on the burning rate involved analytical consideration of two factors. First, the decrease in the weight flow rate of the air passing through the incinerator that stems from the decreased air density at higher altitudes can be predicted accurately from the blower perfomance data and the known flow resistance of the incinerator. It is fairly certain that the burning rate would decrease at least by an amount corresponding to this predictable percentage decrease in mass air flow. Second, it is possible that a further decrease in the burning

TABLE 1. Data on Selected Emergency Standby-Power Sources

Arrangement	For Model 1, With 7-1/2-hp Motor	For Model 2, With 2-hp Motor
(1) Gasoline engine with belt drive (base, belt drive, and remote fuel tank)		
Cost	$800	$200
Weight	1,000 lb	100 lb
Make of engine	Wisconsin	Briggs & Stratton
Engine horsepower	12-1/2	4
(2) Diesel engine (Fairbanks, Morse) with belt drive (base, belt drive, and fuel tank on engine)		
Cost	$1,500	$760
Weight	800 lb	600 lb
Engine horsepower	10-1/2	5-1/4
(3) Gasoline-engine AC generator, 115/230 volt, single phase, 50/60 cycle, or 230 volt, 3 phase, 50/60 cycle, cost	$1,350 to 1,800	$500 to 1,000
Fairbanks, Morse, or Onan, or Kohler, air-cooled or water-cooled engines (with provision for manual or electric start available)*		
Size	10 kw min 15 kw max	3.5 kw min 5 kw max
Weight	800 to 1,700 lb	240 to 525 lb
(4) Price of blower with attached electric motor	$400	$300

*A generator larger than the maximum size listed here may be needed to provide for reliability in starting the incinerator motors or to provide a reserve for other needs. For use at high altitudes, the normal gasoline engine would have to be modified in order to maintain sea-level power output.

rate may occur because the reduced agitating action may result in a lower fuel-air ratio and thus in a lower flue-gas temperature. In our work, the extent of this effect was estimated on the basis of a comparison of the flue-gas temperatures from field tests made by you at higher altitudes with those obtained previously during experimental burning in our laboratory at an altitude of slightly under 1,000 ft. In addition to these two factors, other pertinent conditions associated with flow resistance were taken into account in estimating burning rates at higher altitudes. These conditions included (1) damper setting, (2) length of stack, (3) the possibility of using a cyclone dust collector, and (4) the effect of the power limitations of the electric motor on the blower.

Tables 2 and 3 show the estimated burning rates for the Model 1 and Model 2 units, respectively, (1) at three altitudes - 1,000, 4,000 and, 8,000 ft, (2) with different blower-wheel sizes and speeds, (3) with or without a full-flow cyclone collector, and (4) with a short or long stack. The burning rates are expressed in terms of per cent of a standard rate, which is defined in a footnote to each table. The percentages shown in parentheses reflect only the expected mass flow rates of air through the units; the burning rates at higher altitudes will be at least as low as those corresponding to these values. The lower percentages which are not in parentheses represent our best estimates of the burning rates under the various conditions and reflect all of the above-indicated factors and conditions; we believe that these estimated percentages are accurate ± 5 per cent for the altitudes used in these tables.

The data shown in Tables 2 and 3 were discussed with you and your associates on June 5 and 6. Their conclusion was that the reduction in

TABLE 2. Estimated Burning Rates for Model 1 Incinerator

Arrangement	Estimated Burning Rates at Following Altitudes, per cent*		
	1,000 ft	4,000 ft	8,000 ft
15-1/2-in. MW wheel, 2,900 rpm (50 cycles)			
Without collector; short stack	103	(94) - 90	(81) - 71
With collector; short stack	(91) - 86	(83) - 75	(72) - 60
With collector; long stack	(85) - 75	(77) - 65	(67) - 51
15-1/2-in. MW wheel, 3,500 rpm (60 cycles)			
Without collector; short stack	100	(92) - 86	(97) - 94
With collector; short stack	100	(92) - 86	(87) - 80
With collector; long stack	(95) - 91	(87) - 80	(81) - 71
17-1/2-in. MW wheel, 2,900 rpm (50 cycles)			
Without collector; short stack	103	103	(90) - 84
Without collector; long stack	103	(98) - 95	(84) - 76
18-1/8-in. AW wheel, 2,900 rpm (50 cycles)			
Without collector; short stack	103	103	(95) - 91
With collector; short stack	103	(98) - 95	(85) - 77
With collector; long stack	103	(92) - 86	(80) - 69
18-1/8-in. AW wheel, belt drive (50 or 60 cycles)			
Without collector; short stack	103	103	(97) - 94
With collector; short stack	103	100	(90) - 84
With collector; long stack	103	(96) - 93	(85) - 77

Note: The standard rate used corresponded to approximately 300-350 lb per hr.
*The burning rates are given in terms of per cent of a standard rate, obtained originally with a 14-1/2-in.-diameter blower wheel at 3,500 rpm at an altitude of about 1,000 ft and with a short stack, for any specific kind of paper.

TABLE 3. Estimated Burning Rates for Model 2 Incinerator

Arrangement	Estimated Burning Rates at Following Altitudes, per cent* 1,000 ft	4,000 ft	8,000 ft
11-5/8-in. MW wheel, 2,900 rpm (50 cycles)			
Without collector; short stack	100 (std)	(91) - 86	(78) - 69
With collector; short stack	(80) - 72	(73) - 62	(63) - 48
With collector; long stack	(72) - 61	(64) - 50	(54) - 37
11-5/8-in. MW wheel, 3,500 rpm (60 cycles)			
Without collector; short stack	100	100	(93) - 89
With collector; short stack	(97) - 95	(88) - 83	(76) - 67
With collector; long stack	(85) - 78	(77) - 68	(67) - 54
12-1/4-in. MW wheel, 2,900 rpm (50 cycles)			
Without collector; short stack	100	(98) - 95	(83) - 75
Without collector; long stack	(89) - 84	(81) - 71	(70) - 58
12-1/4-in. MW wheel, 3,500 rpm (60 cycles)			
Without collector; short stack	100	(97) - 94	(95) - 93
Without collector; long stack	100	(97) - 94	(84) - 77
New AW wheel, 2,900 rpm (50 cycles)			
Without collector; short stack	100	100	(86) - 80
With collector; short stack	(89) - 84	(81) - 73	(70) - 58
With collector; long stack	(78) - 70	(72) - 68	(62) - 47
New AW wheel, belt drive (50 or 60 cycles)			
Without collector; short stack	100	(97) - 95	100
With collector; short stack	100	(97) - 95	(88) - 83
With collector; long stack	100	(90) - 85	(80) - 71

Note: The standard rate used corresponded to approximately 100 lb per hr.
*The burning rates are given in terms of per cent of a standard rate, obtained with an 11-5/8-in.-diameter blower wheel at 2,900 rpm at an altitude of about 1,000 ft and with a short stack, for any specific kind of paper.

burning rate at higher altitudes was significant even without a full-flow cyclone collector used in the system, and that an additional reduction caused by the back pressure of a collector could not be tolerated. In addition, they felt that the relatively large size of a full-flow collector and the heat emitted from it during operation would be disadvantageous at many sites.

During the meeting on June 6, decisions were also made regarding the selection of the sizes of wheels for the blowers as shown in Tables 2 and 3. For the Model 2 incinerator, the maximum wheel size of 12-1/4-in. diameter was chosen, instead of the 11-5/8-in. diameter size previously selected, and was to be incorporated in the present two motor-blower assemblies. This will provide a slight reserve in blower capacity, to compensate for a slight increase in altitude or stack length. The previously selected wheel size of 15-1/2-in. diameter for the blower of the Model 1 incinerator can be readily changed to larger sizes as shown in Table 2; it was decided that the selection of a specific wheel size for use at the higher altitudes will be made subsequently, when additional Model 1 units are procured.

A further study of the possibilities and probabilities of maintaining the maximum burning rate at the higher altitudes is in progress. Although the air flow can be increased to compensate for the reduced air density at the higher altitudes, a limiting value for the air flow will be reached when the velocity of the air and the resulting agitation action become great enough to lift the paper from the burning bed and to plug the grid. Thus, it appears that the maximum burning rates achievable, regardless of the blower capacity, will be limited to values which decrease progressively below 100 per cent as the service altitude increases above 1,000 ft. Accordingly, it is expected that those burning rates which are close to 100 per cent at the 4,000 and

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8,000-ft altitudes as listed in Tables 2 and 3 should probably be revised downward by a few per cent on the basis of this paper-lifting limitation (as was discussed with you on July 13).

Toward the end of this report period, new 12-1/2-in.-diameter wheels were procured and installed, and appropriate damper settings were being determined. The effort remaining to be performed directly on the unit is to conduct burning experiments with both motor-blower compartments at blower speeds corresponding to 50-cycle and 60-cycle operation. Also, final estimates of the effect of altitude on the burning rates will be prepared, and included in the summary report. Additional work will be done on the working drawings, and a list of appropriate precautions which merit attention during fabrication will be prepared; completion of these is expected by about August 15.

The total appropriation on this Task Order was $40,638. As of July 1, 1961, the unexpended balance was approximately $1,300.

Sincerely,

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